OPERATIONAL FORECASTING OF WATER CLARITY

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SUMMARY

The model predicts that water clarity varies tremendously during a typical coastal operation, as seen in the simulated Lidar images predicted by the Generic Lidar Model, which are shown in the background of this poster. This result has important consequences for diver and instrument effectiveness during littoral operations.

REFERENCES

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BACKGROUND

We are developing a three-dimensional optical forecasting capability for Case II waters. This capability addresses the problem of the high spatial and temporal variability of water clarity that has been observed in the littoral ocean. Inorganic sediment is introduced into the coastal ocean by river runoff and resuspension from the bottom. This terrigeneous sediment consists of mud and sand. The sand size particles (> 64 μm) are important because of their large settling velocity and, thus, short-term variability.

Scattering by noncohesive sediments (i.e., sand and silt) is significant and has a deleterious effect on electro-optical imaging system performance. It also degrades diver visibility and LIDAR bathymetry system accuracy. This work is developing a physics-based model to predict the scattering associated with these particles.

METHODS

The Sedimentation Model

This study uses the Littoral Sedimentation and Optics Model (LSOM) to calculate suspended sediment profiles, which are used to compute optical scattering coefficients. LSOM has the following general characteristics:

- Wave-current interaction bottom boundary layer model
- Profiles of multiple size classes of noncohesive sediments
- Bottom roughness algorithm
- Optical scattering algorithm including biogenic particles
- Horizontal advection model for individual sizes
- Mass conservation model for bed evolution

The Bio - optical Model

Scattering due to organic particles can be estimated in a robust way using the following model. Total particle scattering b_T is the sum of organic b_o and minerogenic b_m scattering. The scattering coefficient determined from the bio-optical model is totally organic and divided into an algal component b_a, a bacterial component b_{ba}, and an organic detritus component b_{od}.

$$b_T = b_o + b_m \qquad (1)$$

$$b_o = b_a + b_{ba} + b_{od} \qquad (2)$$

$$b_{od} = \frac{[(a_{od}/a_{od}^{*}) + 0.00029]}{0.42} \qquad (3)$$

where a_{od} is the absorption coefficient for suspended organic detritus and a_{od}^{*} is the specific absorption coefficient for suspended organic detritus. The scattering coefficients b_a and b_{ba} are estimated from published data.

The Minerogenic Optical Scattering Model

The total scattering coefficient for particles of a given radius is given by:

$$b_n = N\sigma_p = N\pi r^2 Q_{sc} \qquad (4)$$

where: N = number of particles; σ_p = total scattering cross section (m²); r = radius of particle; and Q_{sc} = efficiency factor. The total minerogenic scattering b_m is thus given by:

$$b_m = \sum_i N_i \pi r_i^2 Q_{sci} \qquad (5)$$

Diver Visibility Model

A horizontal diver visibility metric is computed for each frequency from the scattering coefficients. The calculation is confined to regions where absorption due to CDOM is negligible compared to the total scattering coefficient. The LSOM horizontal diver visibility (in meters) at 532 nm for a black target can be written to reflect each contributing factor of the overall scattering coefficient:

$$R_{horiz}^{532} = \frac{4.8}{\left(b_{quartz}^{532} + b_{Chl}^{532} + b_{water}^{532}\right)}\omega \qquad (6)$$

or, substituting the assumed value of .8333 for the single scattering albedo ω to bracket the error within 20%:

$$R_{horiz}^{532} = \frac{4.0}{\left(b_{quartz}^{532} + b_{Chl}^{532} + b_{water}^{532}\right)} \qquad (7)$$

LSOM predicts the value for b_{Quartz}^{532}, $b_{water}^{532} = .0022$ and $b_{Chl}^{532} = .3033\langle Chl \rangle^{.635}$ where $\langle Chl \rangle$ is the chlorophyll concentration in mg/m³. Another scattering term due to fine grained sediment can be added in the denominator. R_{horiz} is converted to feet for output.

MODEL VALIDATION

This method has been evaluated for an oceanographic and optical field study that took place at Oceanside, California, during October 1995. A comparison of the predicted scattering coefficients to the bio-optical model suggests that LSOM is capturing the bottom sediment contribution to the optical field.

Comparison of LSOM prediction of scattering profiles using suspended sediment distributions and the bio-optical model in (3). The Quartz line results from subtracting bio-optical model (Organic) from AC-9 measured scattering. The left panel shows comparison of LSOM predicted sizes (shaded) with a hyperbolic particle size model.
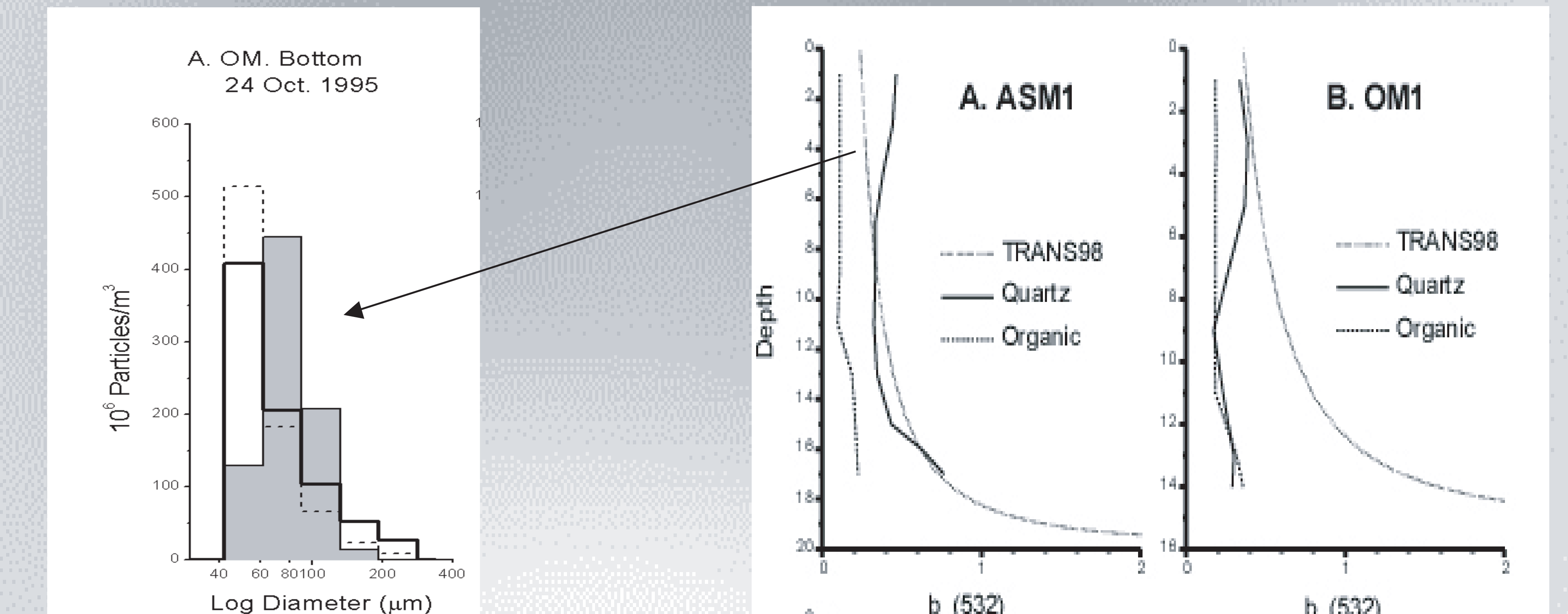
OPERATIONAL TESTING

We have performed operational testing of a forecasting capability for the diver visibility metric on the California coast in support of the Kernal Blitz 2001 exercise. Daily products were produced for a number of operational areas and placed on a web site.
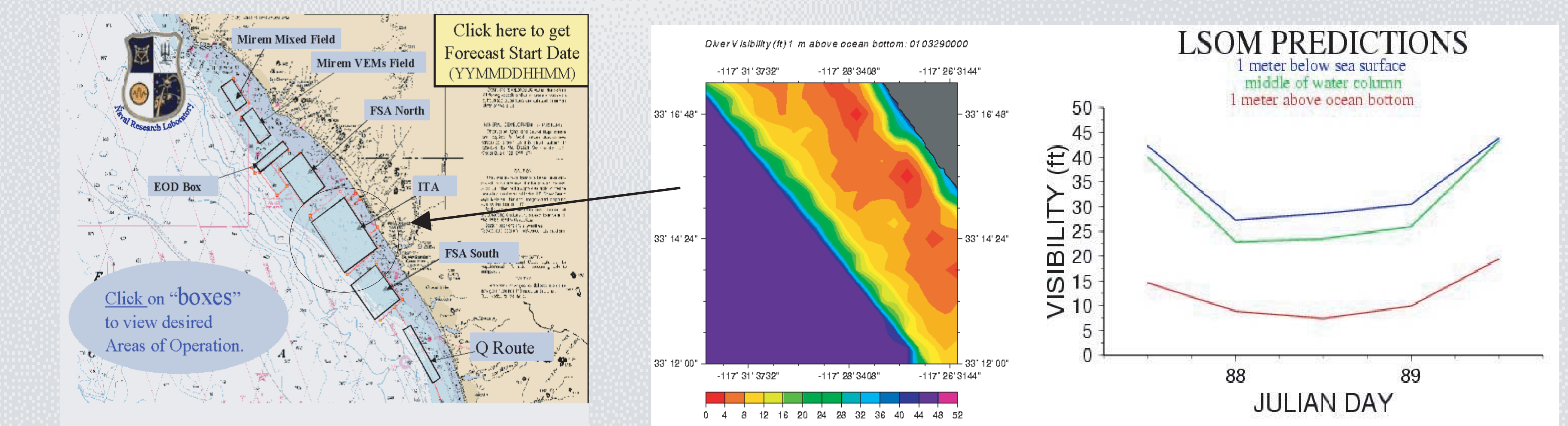
Web Site Main Page   **Diver Visibility (feet)**